Canard Rotor Wing Conversion Test

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The canard rotor wing (CRW) design was initiated by McDonnell Douglas Helicopter Systems (now Boeing) for high-speed, vertical takeoff and landing unmanned air vehicles. The teetering, reaction-drive rotor has a symmetric airfoil, allowing it to be stopped and started in flight with good dynamic performance. Conversion from rotary-wing to fixed-wing flight and vice versa at high speeds is the greatest technical challenge of the CRW. A test of a half-scale model in the Ames 7- by 10-Foot Wind Tunnel (first figure) demonstrated full conversions of the bare rotor at airspeeds up to 150 knots. Rotor loads were benign throughout conversion.

The rotor, which is the critical dynamic component of the CRW vehicle system, is illustrated in the second figure. The rotor provides lift for takeoff and landing as it would in a conventional helicopter. The aft-mounted wing and large canard (forward wing) provide lift in cruising flight, which allows the rotor to be stopped and started while unloaded. With the rotor stopped, the CRW can attain much higher speeds than conventional rotorcraft.

Fig. 1. The CRW rotor (half-scale) in the Ames 7- by 10-Foot Wind Tunnel.

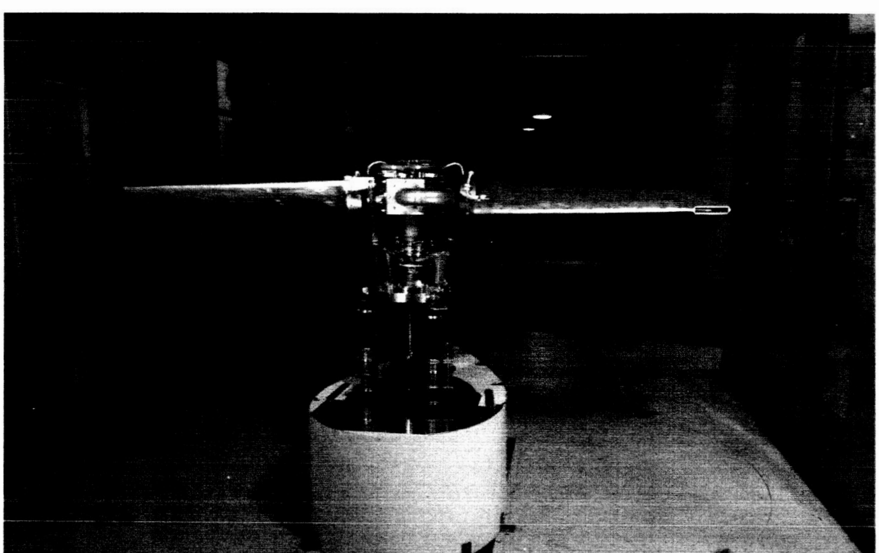

Fig. 2. The CRW fixed-wing model in the Ames 40- by 80-Foot Wind Tunnel.

The rotor is driven by high-pressure air ejected through tip nozzles, which eliminates the need for the usual transmission. The flight vehicle will use turbofan engines to supply high-pressure air to the rotor. In the wind tunnel test, the Ames high-pressure air supply system was used to simulate the engine exhaust.

Previous tests at Ames evaluated performance at high speeds (rotor stopped) and in hover. In the latest test, full conversion was achieved at 150 knots, both with and without hub springs. The test included measurements of rotor loads, stability, control power, and forward flight performance.

Test preparations included addition of a 0.5-megawatt heater to the high-pressure air supply, upgraded air-supply valves, and improved safety protection for the control room. Boeing provided the data-acquisition system.

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Advanced Methods for Testing Rotor Performance

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A principal advantage of rotorcraft is their ability to hover, and the efficiency with which they can hover is fundamental to helicopter productivity. It is surprising, therefore, that the ability to predict hover efficiency (and thus design optimum rotors) is limited. This is because the rotor flow field is so sensitive to the rotor wake that there are large analytical errors. This same wake sensitivity also causes large experimental errors. (If a perfect prediction capability existed, there would be no way to know it, because of experimental error.) Therefore, the attainment of greater rotor analysis capability is a twofold problem of improving both computational and experimental accuracy. This effort is directed at the experimental part of the problem.

Measuring hover performance experimentally is complicated, principally because hover flows are plagued by a range of errors that are related to the

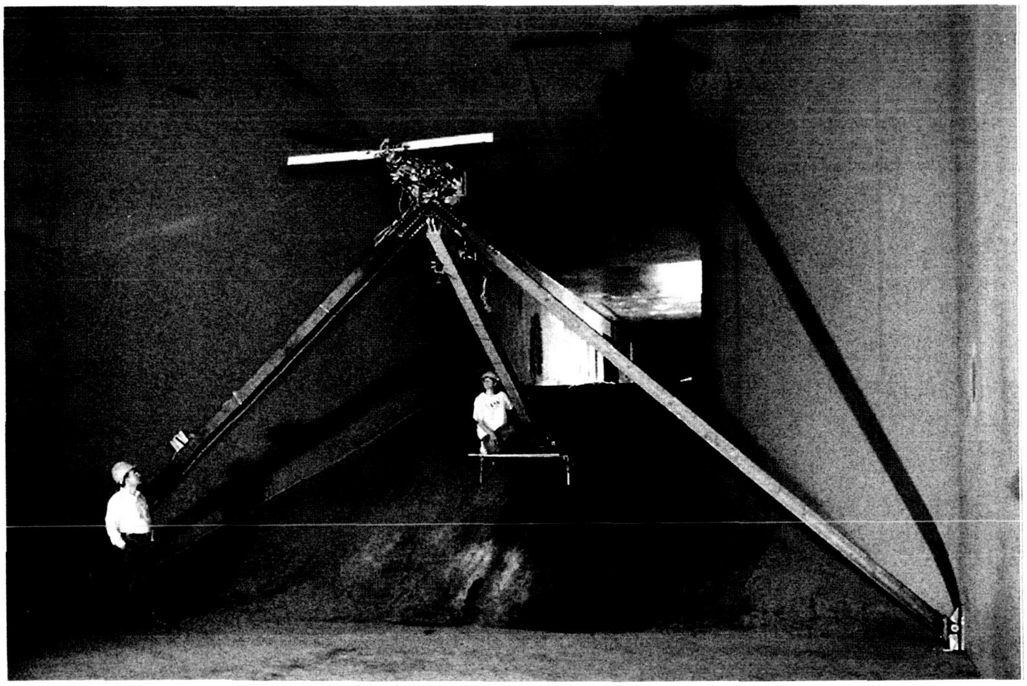

Fig. 1. Setup used to test model rotors in climb.